Patent claims

1. An installation (100) for drying a moisture-containing product (70) from the group comprising individual parts and pourable material, biological material, fuels, foodstuffs, pharmaceuticals and the like with dehumidified air having less moisture than the ambient air or containing a low moisture content of up to 1 g of water/kg of air

- having an apparatus (10) for the dehumidifying of air, within which moist fresh or ambient air (lu) is moved through at least one body (20, 20') or the like consisting of a lumpy, granular and/or porous water-vapor adsorbent through which air can flow and which is based on a silicate-containing material, silica gel or the like, and finally the air (lt) dehumidified there is directed over the product (70) to be dried, which is arranged in a drying chamber (7) or the like, the dehumidifying of the fresh or ambient air (lu) being interrupted within the dehumidifying apparatus (10) when the saturation of the adsorbent body (20, 20') with water is achieved, and the water adsorbed by the adsorbent body (20, 20') being desorbed and expelled from the latter by heating and/or by means of a carrier airflow,
- provision being made for the air-dehumidifying apparatus (10) of the drying installation (100) to comprise at least two installation lanes (I, II),
- having dehumidifying chambers (2, 2'), which are arranged in each case downstream of a feed or inlet chamber (1, 1') for moist fresh or ambient air (lu), accommodate the absorbent body (20, 20') and are in each case provided with a microwave generator or magnetron (6, 6') for the heating of the adsorbent body (20, 20') and through which air

can flow, and at least one discharge (4) on the outflow side of said dehumidifying chambers (2, 2') for the dehumidified air (lt) from the latter,

- furthermore having regeneration-air feeds or charging chambers (5, 5') which are assigned in each case to one of the dehumidifying chambers (2, 2') and from which, directly or by means of regeneration-air conveying means (55, 55'), regeneration air (lr) is directed through the adsorbent body (20, 20') for the desorption of the water, adsorbed by the adsorbent body just mentioned from air (lf) laden with moisture due to the product (70) to be dried, after the saturation of said adsorbent body is achieved,
- and finally having, on the dry-air outflow side of each of the dehumidifying chambers (2, 2'), in each case a three-way changeover or closing member (3, 3'), shutting off or opening up, in each case in opposition to one another, by corresponding changeover, either the path for the dry-air discharge (4) toward the drying chamber (7) or else the path for the regeneration-air feed or charging chamber (5, 5'), or in particular one three-way changeover damper of that kind,

characterized in that its dehumidifying apparatus (10) - for the provision of regeneration air (lr) - has at least one air-conduction line (47, 47') for the air (lf) which is expelled from the drying chamber (7) and contains the moisture received from the product (70) to be dried and which, as regeneration air (lr) provided for the regeneration of the adsorbent body (20) laden or saturated with water, can in each case be directed periodically to the regeneration-air feeds or charging chambers (5, 5') or to one of their regeneration-air charging fans (51, 51') and can be introduced into one

of the adsorbent bodies (20, 20') in one of the air-dehumidifying chambers (2, 2') and can be moved through the same.

2. The installation as claimed in claim 1, characterized

- in that, in its dehumidifying apparatus (10), the fresh or ambient air (lu) - in each case in an alternating manner - can flow first through one (2) of the dehumidifying chambers (2, 2') of a first installation lane (I) or its first adsorbent body (20), regenerated beforehand, with a first microwave generator (6) switched off and with a first three-way changeover or closing member (3) open for the dry-air discharge (4) into the drying chamber (7) and closed toward the regeneration-air feed or charging chamber (5), in a first direction (r1) from the first fresh- or ambient-air feed or inlet chamber (1) toward said dry-air discharge (4),
- while essentially at the same time the regeneration air (lr) can flow through the other or second dehumidifying chamber (2') of a second installation lane (II) having the second adsorbent body (20') laden or saturated there with water, with a second microwave generator (6') switched on and active in terms of heating, and with a second three-way changeover or closing member (3') closed toward the dry-air discharge (4) and open toward the regeneration-air feed or charging chamber (5'), in the second direction (r2), opposed to the first throughflow direction (r1), from the second regeneration-air feed or charging chamber (5') to the second fresh- or ambient-air feed or inlet chamber (1'), and

- in that, during a significant increase in the moisture content of the dehumidified air (lt), flowing through the dry-air discharge (4) toward the drying chamber (7) and flowing out of the first adsorbent body (20) of the first installation lane (I), beyond a respectively predetermined moisture level and/or during a decrease in the moisture of the regeneration air (lr) leaving the dehumidifying chamber (2') and then flowing through the respective fresh- or ambient-air inlet chamber (1') of the second installation lane (II) and finally delivered to the environment,
- by changeover of each of the three-way changeover or closing members (3, 3'), this changeover being controlled by means of the monitoring and control unit (8) supplied with measuring data from sensors (89, 89', 89''; 86, 86'), the first dehumidifying chamber (2) containing the now water-laden first adsorbent body (20) of the first installation lane (I), with the first microwave generator (6) there being switched on or activated, can be changed over to adsorbent regeneration operation (RB), and the second dehumidifying chamber (2'), containing the freshly regenerated adsorbent body (20'), of the second installation lane (II), after the second microwave generator (6') there has been switched off, can be changed over to air-dehumidifying operation (EB).

3. The drying installation as claimed in claim 1 or 2, characterized

- in that, for the movement or conveying of the fresh or ambient air (lu) through the respective adsorbent body (20, 20') and of the air (lt) dehumidified by means of the latter through the

dry-air discharge (4) of the air-dehumidifying apparatus (10), at least one suction fan (41) - generating a vacuum (du), preferably of about 100 to 400 mbar, lying below the ambient pressure, in said discharge (4) - is arranged in the dry-air discharge (4), and the dry air (lt) can be introduced on the pressure side by means of this suction fan (41), at a positive pressure (dü) lying above the ambient pressure, into the drying chamber (7) containing the product (70) to be dried or can be moved fluidically through the chamber (7) and over or through the material (70), or

- in that, in place of the suction fan (41) in the dry-air discharge (4), a suction fan (71) is arranged in the discharge (57) of the drying chamber (7), this discharge (57) being provided for expelling the air (lf), laden with the moisture extracted from the product (70) to be dried, from the drying chamber (7).

4. The drying installation as claimed in one of claims 1 to 3, characterized in that either each of the two regeneration-air feeds or charging chambers (5, 5') is provided with a separate fan (51', 51) for introducing regeneration air (lr) coming from the drying chamber (7) and for delivering it under positive pressure (dü) through the adsorbent body (20', 20) to be regenerated in each case, or else only one common fan (51) of this kind is provided, which fan (51) can in each case be changed over so as to supply each of these two feeds or chambers (5, 5') with regeneration air (lr).

5. The drying installation as claimed in one of claims 1 to 4, characterized

- in that its dehumidifying apparatus (10), in place of regeneration-air feeds or charging chambers (5, 5'), has at least two discharges (4, 4') for dehumidified air (lt) which are separate from one another and are in each case assigned to one of the dehumidifying chambers (2, 2') with their respective adsorbent body (20, 20') of the installation lanes (I, II) and which are connected to the drying space (7) via air-conduction lines (47, 57) which are connected to said discharges (4, 4') and open into the drying chamber (7) containing the material (70) to be dried or start from there,
- in that the dry-air discharges (4, 4') connected to the air-conduction lines (47, 57) opening into the drying chambers (7) or starting from the latter are at the same time regeneration-air feeds or charging chambers (5', 5') for air (lf) fed back as regeneration (lr) air and laden with moisture of the material to be dried, and
- in that in each case a first and a second suction fan (11, 11') are arranged in a first and in a second air-inlet/outlet opening (12, 12') of the air-inlet chamber (1, 1'), in which arrangement, in each case in an alternating manner or in such a way as to be capable of being changed over periodically, air or ambient air (lu), by means of the second suction fan (11') put into operation and held in operation by the control unit (8) - with the first suction fan (11) stopped at the same time - can be drawn successively through the first installation lane (I), comprising the first fresh- or ambient-air feed or inlet chamber (1), the first adsorbent body (20) and the first dry-air discharge (4), further through a first air-conduction line (47), into and through the drying

space (7) containing the product (70) to be dehumidified and then further, with air (1f) laden with moisture from the dehumidified product (70), as regeneration air (1r) via a second air-conduction line (57), through the installation lane (II), comprising the second regeneration-air feed or charging chamber (5'), the second adsorbent body (20'), delivering the water adsorbed by it to the regeneration air (1r) - when the second microwave generator (6') is put into operation from the control unit (8) - and the second fresh-air feed or inlet chamber (1'), of the dehumidifying apparatus (10) and can finally be delivered to the environment (U), and

- in that, after regeneration of the second adsorbent body (20') has been completed, the second suction fan (11') and the second microwave generator (6') can be shut down and the first suction fan (11) and the first microwave generator (6) of the first dehumidifying chamber (2) can be put into operation, likewise by means of the control unit (8), and the fresh or ambient air (1u) can now be drawn in the opposite direction first through the second installation lane (II) of the dehumidifying apparatus (10), through the drying space (7) containing the product (70) to be dried, and finally through the first installation lane (I) of the air-dehumidifying apparatus (10) and can finally be delivered as doubly moist regeneration air (1ff) to the environment (U).

6. The drying installation as claimed in claim 5, characterized in that a suction fan (51', 41'; 41, 51) assisting the respectively operating suction fan (11', 11) of the air-inlet chamber (1', 1) and put into operation and held in operation synchronously with said

suction fan (11', 11) is in each case additionally arranged in both the first and the second installation lane (I, II) in each case in the region of the transition from the dry-air discharge (4) to the first air-conduction line (47) leading into the drying chamber (7) and in the region of the transition of the second air-conduction line (57), coming from the drying chamber (7), into the regeneration-air feed or charging chamber (5') (identical to the dry-air discharge (4') of the second installation lane (II)).

7. The drying installation as claimed in one of claims 1 to 6, characterized

- in that its dehumidifying apparatus (10) has at least two dry-air discharges (4, 4') for dehumidified air (lt) which are separate from one another and are in each case assigned to one of the dehumidifying chambers (2, 2') with their respective adsorbent body (20, 20') of the installation lanes (I, II) and which are connected to the drying space (7) via the air-conduction lines (47, 57) which are connected to said discharges (4, 4') and open into the drying space (7) containing the material (70) to be dehumidified,
- in that the dry-air discharges (4, 4') just mentioned are at the same time regeneration-air feeds or charging chambers (5, 5') for air (lf) discharged from the drying chamber (7) and laden with the moisture from the material to be dried,
- in that a suction fan (71) is arranged in one (57) of said air-conduction lines (47, 57),
- by means of which suction fan (71) fresh or ambient air (lu) is successively drawn through the first fresh- or ambient-air feed or inlet chamber (1), through the first adsorbent body (20) and

through the first dry-air discharge (4) of a first installation lane (I), further via the first air-conduction line (47) through the drying space (7) containing the product (70) to be dehumidified, and then further with the moisture from the dehumidified product (70), and the moist air (1f), which is under the pressure-side pressure of the suction fan, is moved or conveyed as regeneration air (1r) via an air-conduction changeover member (357), in particular a cross changeover damper, the second regeneration-air feed or charging chamber (5') (which is at the same time the dry-air discharge (4')), the second adsorbent body (20'), delivering the moisture to the regeneration air (1r) by means of the second microwave generator (6') put into operation and held in operation by the control unit (8), in the second dehumidifying chamber (2') and the second air-inlet chamber (1'), through which the air originating from the product (70) to be dehumidified and containing the water desorbed by the adsorbent body (20') has flowed, of the second installation lane (II) and is finally delivered to the environment (U), and

- in that, by means of the control unit (8), after regeneration of the second adsorbent body (20') has been completed, the air-conduction changeover member (357), in particular the cross changeover damper, can be changed over and, when the second microwave generator (6') is switched off essentially at the same time by means of the control unit (8), the first microwave generator (6) of the first dehumidifying chamber (2) of the first installation lane (I) can be put into operation, and the fresh or ambient air (1u), by means of the suction fan (71) in the air-

conduction line (57), can now be successively drawn in the opposite direction first through the second installation lane (II), via the first air-conduction line (47) and through the drying space (7) containing the product (70) to be dehumidified and is then moved or forced, under the pressure-side pressure of the suction fan (71), through the first installation lane (I) of the air-dehumidifying apparatus (10) and is finally delivered to the environment (U).

8. The drying installation as claimed in claim 7, characterized in that the fresh- and ambient-air feeds (1, 1'), through which doubly moisture-laden regeneration air (lff) and fresh or ambient air (lu) can flow in each case in an alternating manner, is designed as a heat exchanger (111) which transfers the heat of the doubly moisture-laden regeneration air (lff), discharged from the microwave-heated adsorbent body (2, 2'), of one of the installation lanes (I, II) into fresh or ambient air (lu) directed into the respectively regenerated adsorbent body (2, 2') of the respective other installation lane (II, I).

9. The drying installation as claimed in claim 7 or 8, characterized

- in that fresh-air partial flow or bypass lines (67, 67') bypassing the installation lanes (I, II) branch off from the fresh- or ambient-air feeds (1, 1'), which fresh-air partial flow or bypass lines (67, 67') open into the air-conduction line (47) connected to the drying space (7), in each case in such a way that they can be regulated in terms of flow rate by means of a shut-off member (677, 677'), and by means of which fresh-air partial flow or bypass lines (67, 67'), in

addition to the air (lt) dehumidified in each case when passing through one of the installation lanes (I, II), a partial flow of fresh or ambient air (tlu) can be introduced into the air-conduction line (47),

- in that, furthermore, the two fresh-air partial flow lines (67, 67') are connected to one another by a connecting line (676) having a short-circuit member, in particular a short-circuit damper (667), and
- in that, if need be, an airflow choke or closing member (477) is furthermore arranged in the air-conduction line (47) for setting a respectively desired vacuum (du) in the drying chamber (7).

10. The drying installation as claimed in one of claims 1 to 9, characterized in that at least one moisture measuring sensor (89, 89', 89''), preferably with temperature compensator, for determining or measuring the moisture content of the air (lt) dehumidified by means of the first adsorbent body (20) in the installation lane (I, II) which is in dehumidifying operation (EB) in each case or of the moisture-laden regeneration air (lff) coming out of the microwave-heated, second adsorbent body (20') of the second installation lane (II, I) is arranged at least in each of the two fresh- or ambient-air feeds or inlet chambers (1, 1') of the two installation lanes (I, II) of the air-dehumidifying apparatus (10) and at least in the dry-air discharge (4, 4'), which moisture measuring sensors (89, 89', 89'') are connected for the flow and exchange of measuring data to the monitoring and control unit (8), which is connected for the flow and exchange of control data to the closing members (3, 3'), which can be changed over in each case in opposition to one another, or else to the air-

conduction changeover member (357), in particular a cross changeover damper, and if need be also to the airflow choke or closing member (477) and/or to the short-circuit member (667), in particular a short-circuit damper.

11. The drying installation as claimed in one of claims 1 to 10, characterized in that, in addition to or as an alternative to the moisture measuring sensors (89, 89', 89''), a sensor (86, 86') for detecting a significant change in the current intensity or voltage of the power consumed by the microwave generator (6, 6') switched on in each case is provided, and this sensor (86, 86') is connected for the flow and exchange of measuring data to the monitoring and control unit (8), which is connected for the flow and exchange of control data to the three-way changeover members (3, 3'), which can be changed over in opposition to one another in each case, or to the air-conduction changeover member, in particular a cross changeover member (357), and if need be also to the short-circuit damper (667) and/or airflow choke or closing member, in particular a choke damper (477), and/or to the suction fans (11', 51'; 11, 41) which can be put into operation or switched off in each case in opposition to one another.